



PLAN DE TEST



Date : 22 JANVIER 2003

Objet : **FM DPD Verification Plan**

N/Réf : SEDI-GLAT-Y05-291PB

LAT-SS-01454-01

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Feuilles : Page 1 of 11 Annexe :

Pour Application ou/et Utilisation :

Pour information :

Change History log

PB	28/01/03	J.Cretolle + Eval only on cold temperature	Ph.Bourgeois		
PA	22/01/03		Ph.Bourgeois		
Ind.	Date	Modifications	Visa Auteur	Visa RAQ	Visa Appro.



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1 INTRODUCTION

1.1 Purpose

This document describes the test plan, which will be implemented on the new Dual PIN PhotoDiodes (DPD) from HAMAMATSU filled with silicone resin (KJR9022).

1.2 Historical records

We have already performed a complete test plan on the first DPD S8576, the one filled with epoxy resin (DR1 to DR16). Most of the tests were valid, but there were some issues:

- Delaminations and cracks appear at low temperature (at -30°C)
- The polishing of the epoxy window induces trapezoidal shape of the ceramic substrates (delta thickness up to $200\mu\text{m}$)
- Crack on the leads (especially lead #3)
- Corrosion of the leads (at the kovar level under the gold plated).

The CAL project team has therefore decided to change the encapsulant (Silicone resin is now the baseline) and to order the DPD with leads degolded and tinned before their assembly. He needs also to reduce the sizes of the DPD (1mm width and length) and to move the location of the leads as the external connections are now done with wires instead of Kapton flex. This leads to redesign the ceramic substrate and to reduce by 0.5mm the die B.

Remark: a backup solution for the encapsulant is under study: epoxy resin with silicate glass balls.

There is now a new specification (DA2) for the Flight DPD and a new DPD number: S8576-01.

The philosophy of the different tests & Quality Control are explained in DR19.

1.3 Scope

Taking into account the experience and the results of the tests perform on the S8576, this document define a lighten evaluation then the qualification and the acceptance tests of this new S8576-01.

1.4 Out of Scope

The DPD have to be first transformed in PDA and then bonded on a crystal (one at each ends) to make a CDE. Evaluation and qualification of the both process with this new S8576-01 will be performed. This document does not describe these tests, which are described in dedicated documents (DR17, DR18).



1.5 Documents

1.5.1 Applicable documents

DA1	LAT-SS-00788-013-D5	LAT Environmental Specification 10 Dec 2002
DA2	LAT-DS-002090-10	Specification for the CAL Flight Dual PIN Photodiode 26 Dec 2002
DA3		Flight DPD Handling & Storage procedure
DA4	SAP-GLAST-E06-277-PA	Spécification banc de test BAD-DC
DA5	SAP-GLAST-E06-278-PA	Spécification banc de test BAD-CAPA
DA6	SEDI-GLAST-E06-293-PA	Spécification banc de test BAD-Photosensibilité

1.5.2 Reference documents

DR1	LAT-SS-00391-01 (CEA)	Dual PIN photoDiodes Tests Plan
DR2	E01P1435 (SERMA)	HAMAMATSU photodiodes (DPD-S8576) Evaluation report
DR3	E02P0638 (SERMA)	HAMAMATSU photodiodes (DPD-S8576) Evaluation N°2
DR4	E02P1100 (SERMA)	Failure analysis of four DPD-S8576 from HAMAMATSU
DR5	E02P1385 (SERMA)	HAMAMATSU photodiodes (DPD-S8576) Evaluation N°3
DR6	E02P1443 (SERMA)	HAMAMATSU photodiodes (DPD-S8576) Evaluation N°4
DR7	E02P1503 (SERMA)	Epoxy resin analysis of DPD-S8576 from HAMAMATSU
DR8	LAT-TD-00444-01 (CEA)	Report of the tests performed on the 50 + 200 first DPDs at Saclay
DR9	SAP-GLAST-Y-05-216-DA	Mechanical and electrical measurements of the 100 DPD's for GLAST EM
DR10	SEDI-GLAST-N05-204-PA	ANOMALIES ON DPD pins (cracks and notches)
DR11	SED-GLAST-Y-05-130-PA	Report on the DPD optical measurements at Saclay
DR12	SED-GLAST-Y-09-258-P	DPD Irradiation Test
DR13	SEDI-GLAST-Y-05-223PA	Tests de connexions des DPD à l'aide de fils non torsadés
DR14	E02P1074 (SERMA)	Section on leads of a PIN photodiode after gold removal.
DR15	E02P1865 (SERMA)	Analysis on external leads of DPD from Hamamatsu 13 Jan 2003
DR16	LAT-DS-00072-03	Specification for the Calorimeter PIN Photodiode Assembly Feb 2001
DR17	SEDI-GLAT-Y08-276PA	Qualification des collages EM/FM et Evaluation du collage FM
DR18	Sap-GLAT-Y07-****	PDA Verification Plan
DR19	SEDI-GLAT-Y05-248-DE	Flight DPD Test-QC Philosophy
DR20	SEDI-GLAST-Y-09-229-PA	TEST PLAN : CDE Operation from -10°C to 30°C

1.6 Acronyms

GLAST	G amma- R ay L arge A rea S pace T elescope
LAT	L arge A rea T elescope
CAL	C ALorimeter
DPD	D ual P IN photo D iode
PDA	P IN photo D iode A ssembly (DPD + wires)
DPA	D estructive P hysical A nalysis
CDE	C sl D etector E lements
ESD	E lectro S tatic D echarge



1.7 Definitions

mn	minute
μm	micrometer
CsI(Tl)	Cesium Iodine doped with Thallium

2 EVALUATION

2.1 Destructive Physical Analysis

This DPA will look more particularly:

- The adhesion of the silicone resin at the different interfaces.
- The concavity of the silicone window
- The die attach
- The leads and their connection to the ceramic substrate
- The lead solderability

2.2 Humidity sensitivity

As for the previous DPD filled with epoxy resin we need to know the humidity absorption and desorption of the new encapsulant (silicone resin); In particular to define the baking process of the DPD before bonding (80°C, 24h for the epoxy resin).

Remark: the DPD handling process requires an air conditioning:

- RH: 45+/-5%
- Temperature: 20+/-5°C

So there will be two absorption test conditions:

- Limite condition: RH 50%, 25°C
- Extreme condition: RH 90%, 50°C

2.3 Temperature sensitivity

The requirement is (DA1):

- Acceptance Temperature: -20°C to 30°C (in operation)
- Qualification and survival: -30°C to 50°C (off).

Hamamatsu S8576-01 performances:

- Operation Temperature: -40°C to 100°C (in operation)
- Storage: -40°C to 125°C (off).

There will be three kinds of test:

1. The first test will consist to estimate the margin we have in temperature the DPD being Off. The criteria will be mechanical (delaminations and cracks), electrical (loose of contact) and optical (green photosensitivity). The test consists in thermal cycling with increasing temperatures:
 - Number of cycles: 40
 - Ramp rate: 1 to 2°C/mn



- ½ hour dwell at the minimum and maximum temperatures

As the upper limit given by the manufacturer is a factor 2.5 greater than the requirements, we only look at the cold temperature. The temperature of the thermal cycling are:

- -25°C to 20°C (40 cycles)
- -30°C to 20°C (40 cycles)
- -35°C to 20°C (40 cycles)
- -40°C to 20°C (40 cycles)
- -45°C to 20°C (40 cycles)
- -50°C to 20°C (40 cycles)

2. The second test will be an increase of the number of thermal cycling at the storage limit temperature (-30°C to 50°C). The ramp and the dwell time as well as the criteria will be the same than the above previous test.
The number of thermal cycling will be increased by step of 20 and DPD will be remove for inspection and control at each step (20, 40, 60, 80, 100).
3. The third test will be an operating test (pedestal and spread/peak of an radioactive X source variation) of DPD from -20°C to 30°C, at different bias voltage of the DPD (70V nominal, 100V max, fluctuation of the nominal value TBD).

2.4 Radiation hardness

The requirement is 100Gy (10Krad). The criteria of success will be the Dark Current (which we have previously evidenced a sensitivity) and the green photosensitivity (optical transmission of the silicone resin)

2.5 Photodiode Active Area scan

PIN Photodiode active area scans have been performed on the S8576 filled with epoxy resin (DR11).

We will redo the measurements with the DPD filled with the silicone resin (Hamamatsu will fill window-less S8576 with silicone resin).

2.6 ESD sensitivity

Study of the ESD sensitivity of DPD to be written by J.Cretolle

3 QUALIFICATION

The qualification, which corresponds to the DPD assembly, will be performed on 60 DPD (about 10%) of the first delivery of the FM DPD. It corresponds to the Lot Acceptance Qualification tests of the FM DPD Specification (DA2).



Remark: There will be intermediate qualifications of the different elements of the DPD: the ceramic substrate lots, the lead tinning lots and the dies lots (see DA2, DR19).

From DA2: Table 9. Lot Acceptance Qualification (Test to be performed by CEA on DPDs screened)

S / N	Test	MIL-STD-883		Quantity
		Method	Condition	
1	Visual Inspection		As per para. 6.4.13	60
2	Acoustic Microscopy			60
3	Electrical Verification	As specified herein	As per table 8A & 8B	60
4	Physical dimensions	As per figure 1	As per para. 6.4.14	60
	Solderability	ANSI/J-STD-002		1
	Resistance to solvents & fluxes	2015		3
S / N	Test	MIL-STD-883		Quantity
5	Moisture Intake	JESD-22-A113	168 hrs, +50°C, 50%RH	6 out of lot of 60
6	Electrical Verification after moisture intake testing	As specified herein	As per tables 8A & 8 B	6
7	Acoustic Microscopy on parts tested during step 5			6
8	Visual Inspection of parts tested during step 5. These parts will not be tested again and stored separately	2032	As per para. 6.4.13	6
9	Steady-state life and End-point electricals, as per tables 8A & 8B	1005	1000 hours at 60°C	22 out of lot of 60
10	Thermal cycle	1010	* 60 cycles at -30°C to +50°C at ramp rate not exceed 1°C/minute with ½ hour dwell at each temp.	10 out of lot of 60
11	Electrical verification after thermal cycling step 8	As specified herein	As per table 8A & 8B	10
12	Acoustic Microscopy on parts tested in step 9			10
13	Visual Inspection on parts tested during step 9. These parts will not be tested again and stored separately	2032	As per para 6.4.13	10
14	Radiation Testing	Per para. 7.1	Total Ionizing Dose testing	3 out of lot of 60
15	DPA Perform the following tests on the parts tested in step 5 and step 10 (one from each test device): - Radiography - SEM Analysis - Ceramic Substrate Evaluation - Die Attachment and Wirebond Evaluation (wirebond evaluation may be subjective due to attachment of optical silicone resin to the wirebond)			2



4 ACCEPTANCE TESTS

The acceptance tests will be performed on each delivery lot of the FM DPD. They correspond to the incoming inspection at Saclay of the FM DPD (DA2) .

Remark: The DPD will be stored in dedicated boxes. An individual protective film will protect the silicone window. They will be a handling and storage procedure for the DPD (DA3), describing the ESD and cleanliness precautions.

4.1 Visual inspection

A visual inspection will be done on all DPD (probably the longer inspection task). Any anomaly will be noticed on the DPD individual sheet and could lead to DPD rejection.

4.1.1 General

- Foreign material that can be wiped off should be acceptable, and if so, removed and noticed on the DPD individual sheet, as an anomaly.
- Ceramic substrate should be clear of silicone resin.

4.1.2 Window side

- There will be a minimum clearance of 100µm between dies and the ceramic walls.
- Foreign material and bubbles (in active area) in the silicone resin window of DPD should be examined under a magnification of 4-10X. Any bubbles greater than or equal to 200µm in diameter should be considered as a default.
- No delamination and micro-cracks.
- The concavity of the silicone window does not exceed 150µm and in any case a wirebond shall be not covered by encapsulant.
- Ceramic substrate edges should be clear of silicone resin.

4.1.3 Leads

- Leads scratches, abnormal bending, should be rejected.
- No lead rework allowed (prior to approval from NRL / CEA).
- Lead alignment and bonding.
- Leads tinning shall be examined for clean, smooth, bright tinning finish, excessive solder (including peaks, via holes are not allowed).

4.2 Mechanical inspection

The mechanical inspection will be performed on sample (10% randomly of each delivery lot). Any deviation of the measurements from the DPD specification should lead to the rejection of the entire delivery lot.

- The concavity of the silicone window: 0 to 150µm



The accuracy of the measurement should be about 10 to 20 μ m and without any degradation of the window. An optical equipment as a microscope should be used (the thickness could be measured at the same time).

If the results on the bare ceramic substrates lot qualification show no significant dispersion, the following controls could be perform on smaller sample.

- Size of the DPD:
 - Width: 13.8 to 14.1mm, 14.0mm nominal
 - Length: 21.1 to 21.4mm, 21.3mm nominal
 - Thickness: 1.60 to 1.96mm, 1.78mm nominal
- Position of the 4 leads:

This control will not induce any lead degradation on the 4mm length close to the ceramic substrate (the soldering length is 2mm the remaining will be cut).

As the position, which has to be controlled, is at the ceramic substrate level, an optical method should be the best way (the width and length could be measured at the same time). The accuracy will be of 0.1 to 0.2mm.



4.3 Electrical inspection

The electrical inspection will be performed on sample (10% randomly of each delivery lot). Any deviation of the measurements from the DPD specifications should lead to the rejection of the entire delivery lot.

- The Dark Current of both PIN A & B (DA4)
- The Thermal Capacitance (DA5)

The specifications are summarized in the following Table 8A & 8B of DA2:

Table 8A – PIN A (Small diode)

Parameter	Symbol	Condition	Min.	Type	Max.	Unit	Sampling
Photo Sensitivity	S	$\lambda = 540 \text{ nm}$	0.35	0.38	0.41	A/W	100%
Dark Current	I_D	$V_R = 70 \text{ V}$	0.2	1.0	3.0	nA	100%
Terminal Capacitance	C_t	$V_R = 70 \text{ V}, f = 1 \text{ MHz}$	12	14	16	pF	100%

Table 8B – PIN B (Large diode)

Parameter	Symbol	Condition	Min.	Type	Max.	Unit	Sampling
Photo Sensitivity	S	$\lambda = 540 \text{ nm}$	0.35	0.38	0.41	A/W	100%
Dark Current	I_D	$V_R = 70 \text{ V}$	0.5	2.5	7.5	nA	100%
Terminal Capacitance	C_t	$V_R = 70 \text{ V}, f = 1 \text{ MHz}$	54	63	72	pF	100%

4.4 Optical inspection

The photosensitivity inspection (DA6) will be performed on sample (10% randomly of each delivery lot). Any deviation of the measurements from the DPD specification should lead to the rejection of the entire delivery lot. The specification are summarized in the herein Table 8A & 8B of DA2. The measurements will be performed with a pulsed green LED (526nm), and will be relative to reference DPD (taken on the first lot in accordance with Hamamatsu).

5 GENERAL PLAN & SCHEDULE

5.1 DPD supply

- 8 to 11 S8576 filled with silicone resin: available week 6
- 20 S8576-01 window-less: available week 7 to 8
- 184 S8576-01 filled with silicone resin: available week 8 to 9
- 600 Flight DPD, the first delivery S8576-01: end June 2003



5.2 Plan

- 8 to 11 S8576 filled with silicone resin:
Beginning of the evaluation DPD (4 to 7), CDE evaluation
- 20 S8576-01 window-less
Die evaluation (EBIC?), Backup encapsulent (epoxy resin + micro glass ball)
- 184 S8576-01 filled with silicone resin
Evaluation of DPD (30 to 40), PDA, Bonding process, CDE and practice
- 600 Flight DPD, the first delivery S8576-01:
DPD Qualification (60), QM CDE

All these DPD will first go through the acceptance test (minimum 10% of the 600 Flight DPD of the first delivery).

5.3 Schedule

- To be Written

6 HANDLING & STORAGE

6.1 Handling

- The Dual Pin photodiode will be handled with gloves
- ESD precautions will be taken
- The humidity will be controlled (45+/-5%) and measured.
- The temperature will be controlled (20+/-5°C) and measured.

6.2 Storage

- The humidity will be controlled (<40%) and measured.
- After measurement the DPD will be reconditioned in hermetic "dry bag" (vacuum thermo-soldered plastic bag).

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